RESEARCH ARTICLE

VARIABILITY IN SEED TRAITS AND CHLOROPHYLL SPECTRUM OF EXOTIC BAMBARA NUT GERMPLASM

P. Pranusha, N. Sivaraj, B. Parameswari, Pratibha Brahmi* and K. Anitha

ICAR-National Bureau of Plant Genetic Resources, Regional Station, Hyderabad 500 030, Telangana
[*]ICAR-National Bureau of Plant Genetic Resources, New Delhi 110012

Received-03.03.2022, Revised-17.03.2022, Accepted-28.03.2022

Abstract: The Bambara groundnut [*Vigna subterranea* (L.) Verdc.] is an underutilized nutrient rich legume crop. This crop is widely cultivated in Africa and Asia. It is mainly grown by poor farmers in semi-arid parts of African countries. It is one such imperative and neglected legume crop that contributes positively to improving global food and nutrient safety. It has great potential for incorporation into various human foods in India, where it could provide useful plant proteins. Variability in seed morphological traits were carried out on exotic bambara nut germplasm (33) imported from four African countries *viz*., Ghana, Niger, Tanzania and Uganda and as to group and identify unique germplasm based on seed traits and total chlorophyll content of germplasm. Twenty seed colour morphotypes in bambara nut were identified in the present study. The promising lines for seed traits were also presented.

Keywords: Bambara nut, Seed morphology, Seed colour, Chlorophyll content

INTRODUCTION

Bambara nut (*Vigna subterranea* (L.)Verdc) is a potential exotic African legume crop, which plays an important role in the nation's nutritional and food security. It is grown for its underground seed. It is also called as bambara groundnut, bambara-bean, Congo goober, earth pea, ground-bean, or hog-peanut. It is a hardy crop due to its drought tolerance, resistance to pests and diseases and ability to yield on poor fertility soils. It has a great potential to establish in similar situations in Asian countries, including India. It was also declared as one of the "crops for the new millennium" (Ahmad, 2012). The seeds of bambara groundnut make a complete food, as it contains sufficient quantities of protein (16-25%), carbohydrate (42-60%), essential amino acids (32.7 %) of total amino acids) and energy (Minka and Bruneteau 2000; Amarteifio *et al*., 2006). In India, the potential states for the cultivation of bambara nut are Rajasthan, Haryana, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh and Jharkhand, where it is being grown as rainfed crop on the poor fertility soils during rainy season.

MATERIALS AND METHODS

A project entitled "*Evaluation of Stress Tolerant Orphan Legumes for use in dryland farming system across sub-Saharan Africa and India-Promoting India-Africa Frame work for strategic Cooperation*" was developed by ICAR-National Bureau of Plant Genetic Resources (NBPGR) with inputs from all African partner countries and funded by Kirkhouse Trust, UK in May 2018. The major objective of this project is collecting and evaluation of the elite germplasm of stress tolerant neglected legume crops including Bambara nut and identification of suitable accessions for multi-locational testing across project partner countries. Under this project 33 bambara groundnut accessions imported from Ghana (10), Niger (9), Tanzania (6) and Uganda (8) during 2020-2021 formed the part of present study. As part of quarantine testing, they were subjected to post-entry quarantine (PEQ) growing and for seed multiplication at ICAR-NBPGR Regional Station, Hyderabad, India. Each accession was grown in three pots with five seeds sown in each pot.

During the post entry quarantine process, as a prelude to characterization and evaluation, selected plant traits including testa with eye pattern around hilum were recorded using the standard descriptors (Bioversity International). Total chlorophyll content was recorded on the terminal third leaf at the time of flowering on five randomly selected plants of each accession using SPAD (Soil Plant Analytical Development) chlorophyll meter (Minolta, USA) and the unit less number displayed is referred as SPAD chlorophyll meter reading (SCMR). It is being used as a simple alternative technique to estimate differences in WUE (Water Use Efficiency), at least as an initial screening. A significant positive relationship between SCMR and chlorophyll content has been reported in many crop species including groundnuts (Sheshshayee *et al*., 2006). Seed traits such as length and width were recorded using digimatic calliper (Mitutoyo Corporation, Japan). Test weight of seed was taken using electronic weighing balance. In addition, a simple workable grouping of the harvested seeds of 33 germplasm accessions was generated based on Royal Horticultural Society's (UK) colour chart. The promising accessions for specific seed traits were also highlighted. Descriptive statistical analyses of seed traits carried out using MS-Excel.

*Corresponding Author

RESULTS AND DISCUSSION

These 33 exotic bambara groundnut accessions broadly classified into six major colour groups Yellow-White (7), Greyed-Purple (5), Greyed-Yellow (5), Greyed-Orange (12), Black (2) and Grey Red(2) (Table 1) and also 20 seed colour morphotypes were identified. Interestingly, the colour group greyed-orange represents highest morphotypes (9) followed by greyed-purple group (4), greyed-yellow group (3), grey-red group (2), yellow-white group (1), and black (1) respectively. Literature indicates that the testa colour in bambara groundnut could be related to drought tolerance traits. Dark-coloured seeds exhibit better emergence rates compared to light coloured seed due to the presence of tannins, which are polyphenols that acted as antioxidant under stress conditions (Mwale *et al*., 2007, Mabhaudha and Modi, 2013).

The 100-seed weight ranged from 26.3 g to 97.0 g with a mean value of 46.62. The promising bambara nut accessions for test weight identified are EC1054950 (97.0g), EC 1054954 (59.8 g) from Uganda and the lowest test weight was observed in Ghana samples EC1050875 (26.3 g) (Table 2). Chibarabada *et al* (2014) reported 100-grain mass for the bambara groundnut landrace selections (plain red, plain cream, brown speckled and black speckled) in a range of 73.29 and 88.05g.

The highest seed length and seed width are recorded in Ugandan accessions EC1054951, EC1054949, respectively. The exotic germplasm exhibited a good variability in seed features such as seed colour (Fig. 1), testa with eye pattern around hilum, test weight, seed length and width (Table 2). Similar variation in seed morphological features had been reported by earlier researchers from the African countries (Massawe *et al*. 2005; Abu and Buah 2011; Mohammed *et al*., 2016). They established that the African bambara nut germplasm possess divergent morphological traits that can be effectively used through breeding programmes. The total chlorophyll spectrum of all the 33 accessions presented in Fig.2. The total chlorophyll content (SPAD Values) ranged from 34.4 to 43.4 units with a mean value of 40.0. Among them EC1054954 recorded the highest value of 43.4 while EC1054950 recorded the lowest value of 34.4. Measurements with the SPAD-502 meter produce relative SCMR values that are proportional to the amount of chlorophyll present in the leaf of bambara nut germplasm (Marquard and Tipton, 1987).

It is observed that the potential diversity of bambara nut has not been fully utilized so far around the world (Massawe *et al*. 2005). However, the divergences in seed traits studied would be useful in crop improvement of bambara nut. Success in bambara groundnut crop improvement depends largely on the genetic variability available in the species. It is evident from previous experiences that use of genetic resources in crop improvement programmes is not up to the desirable extent. This is especially true in a crop like bambara nut due to lack of supply of information needed by breeders from gene banks. Padulosi *et al*., (2011) indicated that the variations in seed coat colour and eye pattern exhibited in the African bambara nut landraces are useful to distinguish the germplasm in crop improvement programmes. Bambara groundnut is a neglected and underutilized crop, which plays an important role in sustaining the impoverished rural population by increasing their available food and protein basket. Concerted efforts are required for the systematic selection of bambara nut germplasm based on seed morphological characteristics for effective breeding would boost crop productivity and quality, and improve food security.

Table 1. Grouping of Bambara nut germplasm based on Royal Horticultural Society (UK) Colour Chart 5th Edition

S. No	Colour Group (number of accessions)	Fan Number of chart	Accesssion (no)
A	Yellow-white (7)	158-A	EC1050866, EC1050867, EC1056417, EC1056420, EC1056421, EC1056424, EC1056425
B	Greyed-Purple (5)	187-A	EC1050868, EC1054955
		187-C	EC1050874
		187-D	EC1050880
		N186	EC1056419
C	Greyed-Yellow (5)	161-A	EC1050871
		161-B	EC1050869, EC1054950
		161-C	EC1054953, EC1054956
D	Greyed-Orange (12)	166-A	EC1054949

		166-C	EC1054951
		N 170 A	EC1054954
		172-A	EC1056418
		172-C	EC1056422, EC1056423
		175-A	EC1050870
		173-D	EC1050873, EC1050872
		173-C	EC1050875
		174-A	EC1050881, EC1050876,
E	Black (2)	203-C	EC1050877, EC1050879
F	Grey Red(2)	178-A	EC1050878
		178-B	EC1054952

Table 2. Seed features variability in the exotic Bambara nut germplasm

Country	Accession (no.)	100 seed weight (g)	Seed length (mm)	Seed width (mm)	Testa with eye pattern around hilum
GHANA	EC1050872	38.1	10.88	8.93	Light brownish red
	EC1050873	52.4	10.81	9.29	Light brownish red
	EC1050874	46.6	9.69	8.06	Dark red
	EC1050875	26.3	9.65	7.79	Light brownish red
	EC1050876	39.4	10.52	8.65	Light brownish red
	EC1050877	43.9	11.37	9.29	Dark red
	EC1050878	33.4	9.78	7.18	Dark brown
	EC1050879	33.9	9.02	8.27	Dark red
	EC1050880	41.6	9.91	7.99	Dark red
	EC1050881	32.3	9.40	8.24	Light brown
NIGER	EC1056417	31.1	9.86	8.20	Cream
	EC1056418	34.2	10.48	8.24	Light brownish red
	EC1056419	41.3	10.73	8.48	Black
	EC1056420	42.5	12.01	9.38	Brown stripes on cream background with black irregular eye
	EC1056421	36.4	10.64	8.45	Cream testa with black irregular eye
	EC1056422	36.6	10.32	7.55	Light brownish red
	EC1056423	38.3	10.64	7.95	Light brown testa with grey butterfly like eye
	EC1056424	49.3	11.23	8.91	Dark brown marbled spots on cream background with grey butterfly like eye
	EC1056425	39.7	11.10	9.20	Cream testa with black irregular eye
TANZANIA	EC1050866	54.8	12.13	9.77	Cream testa with grey butterfly like eye
	EC1050867	44.3	10.20	8.29	Cream testa with dark red butterfly like eye
	EC1050868	57.2	12.24	9.39	Dark red
	EC1050869	58.4	10.76	9.20	Cream testa with black irregular eye
	EC1050870	56.5	12.55	9.47	Light brownish red
	EC1050871	53.3	12.98	10.01	Cream
UGANDA	EC1054949	97.0	14.24	11.12	Black small dotted spots on brown

					background without eye
	EC1054950	55.5	13.30	10.43	Black and brown mottles on cream background with grey butterfly like eye
	EC1054951	53.9	14.32	10.54	Dark brown
	EC1054952	53.7	11.87	8.92	Light brown testa with grey butterfly like eye
	EC1054953	52.4	10.13	8.83	Brown stripes on cream background with grey butterfly like eye
	EC1054954	59.8	12.34	9.45	Light brownish red
	EC1054955	53.1	11.87	9.59	Black
	EC1054956	51.2	10.62	8.73	Brown stripes on cream background with grey butterfly like eye
Descriptive Statistics					
Minimum		**26.3**	**9.02**	**7.18**	
Maximum		**97.0**	**14.32**	**11.12**	
Range		**70.7**	**5.3**	**3.94**	
Mean		**46.62**	**11.14**	**8.90**	
Standard Error		**2.25**	**0.23**	**0.15**	
Standard Deviation		**12.95**	**1.33**	**0.88**	
Coefficient of Variation (%)		**27.8**	**11.7**	**9.9**	

Fig. 1. Seed diversity in select germplasm accessions of Bambara nut from Niger

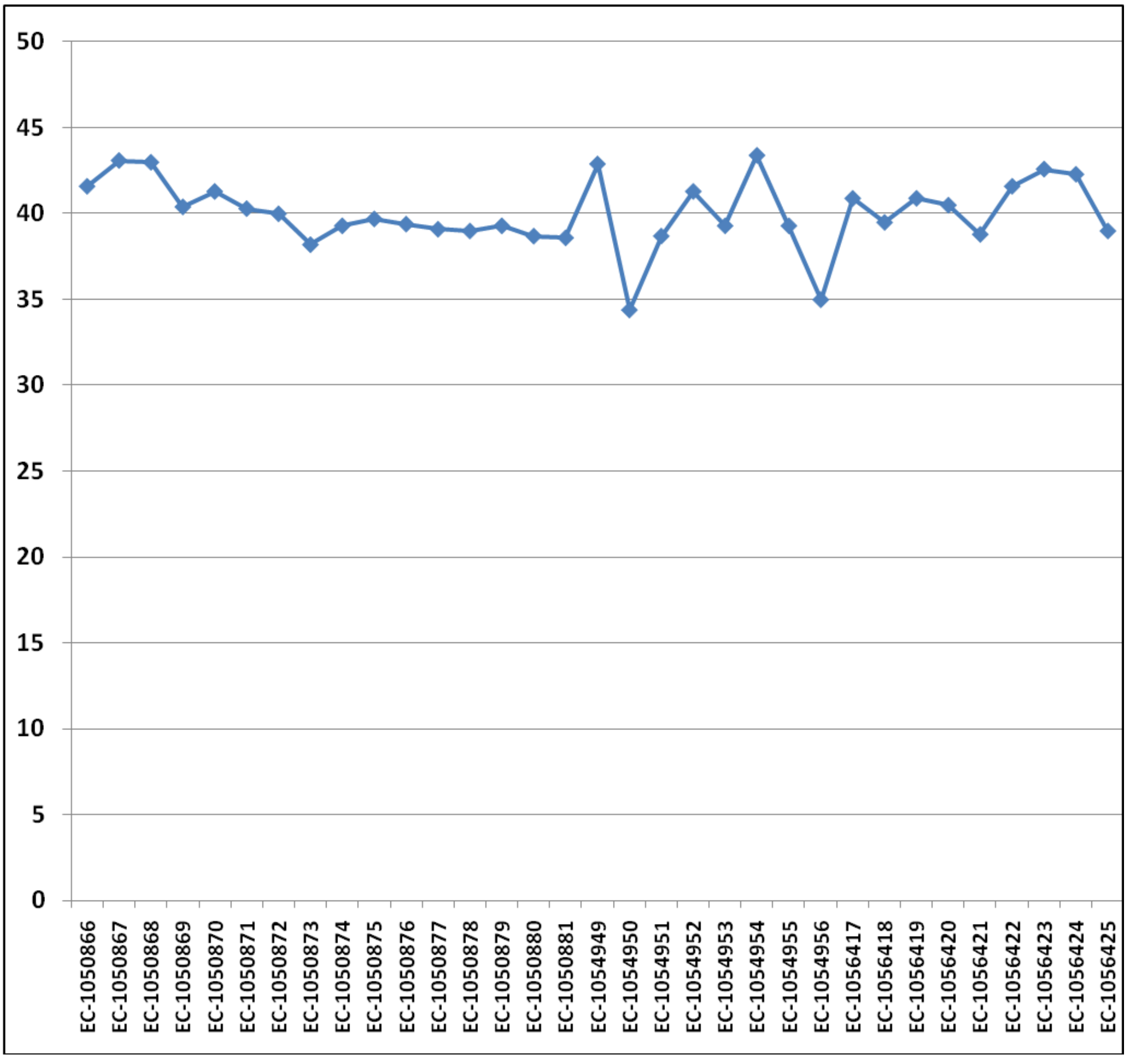

Fig. 2. Total Chlorophyll (SPAD units-Y axis) spectrum in the Exotic Bambara nut germplasm accessions (X-axis)

REFERENCES

Abu, H.B. and Buah, S.S.J. (2011). Characterization of Bambara groundnut landraces and their evaluation by farmers in the upper West Region of Ghana. Journal of Development Sustainable Agriculture (6):64–74.

Google Scholar

Ahmad, N.S. (2012). Bambara Groundnut, the Crop for the New Millennium: Molecular Techniques to Improve the Resiliency of Bambara Groundnut; Lambert Academic Publishers: Sunnyvale, CA, USA.

Google Scholar

Amarteifio, J.O., Tibe, O. and Njogu, R. M. (2006). The mineral composition of Bambara groundnut (*Vignasubterranea* (L) Verdc) grown in southern Africa. African Journal of Biotechnology, 5: 2408–2411.

Google Scholar

Chibarabada, T.P., Modi, A.T. and Mabhaudhi, T. (2014). Seed quality characteristics of a Bambara groundnut (*Vignasubterranea* L.) landrace differing in seed coat colours. African Jouranal of Plant Soil, 31:219-226.

Google Scholar

Marquard, R.D. and Tipton, J.L. (1987). Relationship between extractable chlorophyll and an *insitu* method to estimate leaf greenness. Horticultural Science: 22:1327.

Google Scholar

Massawe, F., Mwale, S., Azam-Ali, S. and Roberts, J. (2005). Breeding in Bambara groundnut (*Vigna subterranea* [L.] Verdc.): strategic considerations. African Journal of Botany 4:463–471.

Google Scholar

Mohammed, M.S., Shimelis, H.A. and Laing, M.D. (2016). Phenotypic characterization of diverse Bambara groundnut (*Vigna subterranea* [L.] Verdc.) germplasm collections through seed morphology. Genetic Resource Crop Evolution 63:889–899.

Google Scholar

Minka S.R. and Bruneteau, M. (2000). Partial chemical composition of Bambara pea (*Vigna subterranea* L. Verdc). Food Chemistry, 68:273–276.

Google Scholar

Mabhaudhi, T. and Modi, A.T. (2013). Growth, phenological and yield responses of a Bambara groundnut (*Vigna subterranea* (L.) Verdc.) Landrace to imposed water stress under field conditions. South African Journal of Plant Soil 30:69–79.

Google Scholar

Mwale, S.S., Azam-Ali, S.N. and Massawe, F.J. (2007). Growth and development of Bambara groundnut (*Vigna subterranea* L.) in response to soil moisture, dry matter and yield. European Journal of Agronomy 26:345-353.

Google Scholar

Padulosi, S., Heywood, V., Hunter, D. and Jarvis, A. (2011). Underutilized species and climate change: current status and outlook. In: Yadav SS, RJ Redden, JL Hatfeld, H Lotze Campen, AE Hall (eds) Crop adaptation to climate change. Wiley-Blackwell, Oxford, pp 507–521.

Google Scholar

Sheshshayee, M. S., Bindumadhava, H., Rachaputi, N. R., Prasad, T. G., Udayakumar, M., Wright, G. C. and Nigam, S. N. (2006). Leaf chlorophyll concentration relates to transpiration efficiency in peanut. Annals of Applied Biology 148:7-15.

Google Scholar